Introduction to Morphology

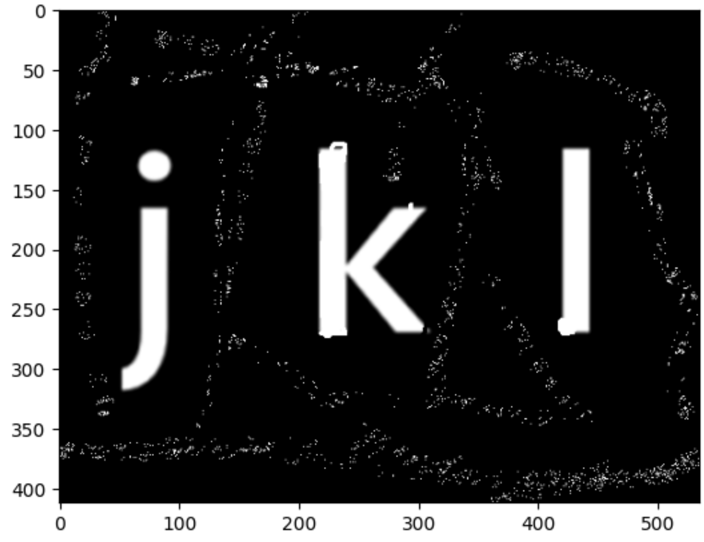
Morphology is a comprehensive set of image processing operations that process images based on shapes [1]. Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors.

There is a slight overlap between Morphology and Image Segmentation. Morphology consists of methods that can be used to pre-process the input data of Image Segmentation or to post-process the output of the Image Segmentation stage. In other words, once the segmentation is complete, morphological operations can be used to remove imperfections in the segmented image and deliver information on the shape and structure of the image as shown in Figure 2.


```
import numpy as np
import cv2 as cv
from matplotlib import pyplot as plt
img = cv.imread('Images/three.jpeg', cv.IMREAD_GRAYSCALE)
img = 255-cv.imread('Images/jkl.png', cv.IMREAD_GRAYSCALE)

plt.imshow(img, cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d46b9410>
```



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1. Erosion

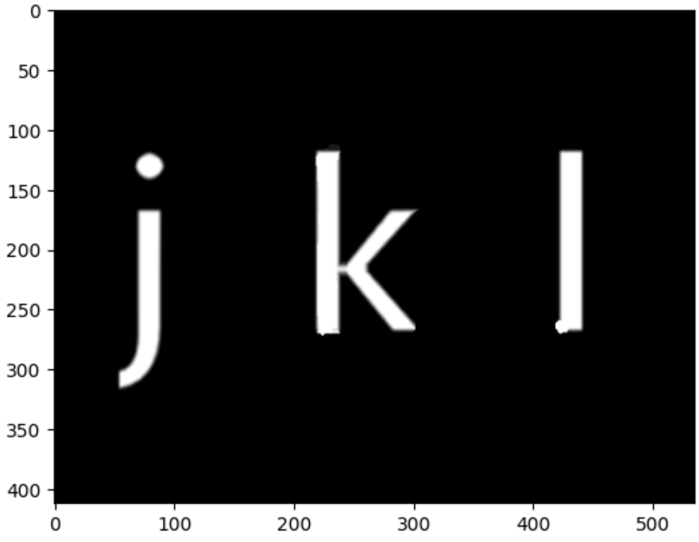
The basic idea of erosion is just like soil erosion only, it erodes away the boundaries of foreground object (Always try to keep foreground in white). So what it does? The kernel slides through the image (as in 2D convolution). A pixel in the original image (either 1 or 0) will be considered 1 only if all the pixels under the kernel is 1, otherwise it is eroded (made to zero).

So what happends is that, all the pixels near boundary will be discarded depending upon the size of kernel. So the thickness or size of the foreground object decreases or simply white region decreases in the image. It is useful for removing small white noises (as we have seen in colorspace chapter), detach two connected objects etc.

Here, as an example, I would use a 5x5 kernel with full of ones. Let's see it how it works:

```
kernel = np.ones((5,5),np.uint8)
erosion = cv.erode(img,kernel,iterations = 1)
plt.imshow(erosion, cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d472f550>
```



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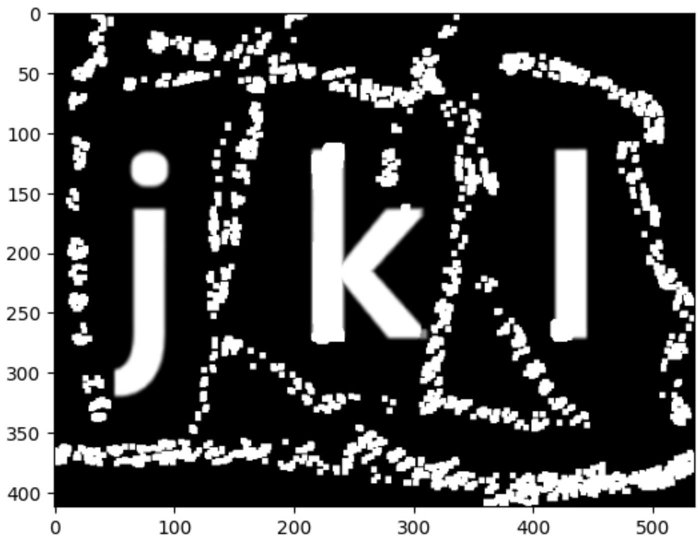
2. Dilation

It is just opposite of erosion. Here, a pixel element is '1' if at least one pixel under the kernel is '1'. So it increases the white region in the image or size of foreground object increases. Normally, in cases like noise removal, erosion is followed by dilation. Because, erosion removes white noises, but it also shrinks our object. So we dilate it. Since noise is gone, they won't come back, but our object area increases. It is also useful in joining broken parts of an object.

```
dilation = cv.dilate(img,kernel,iterations = 1)
plt.imshow(dilation, cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d4717690>
```



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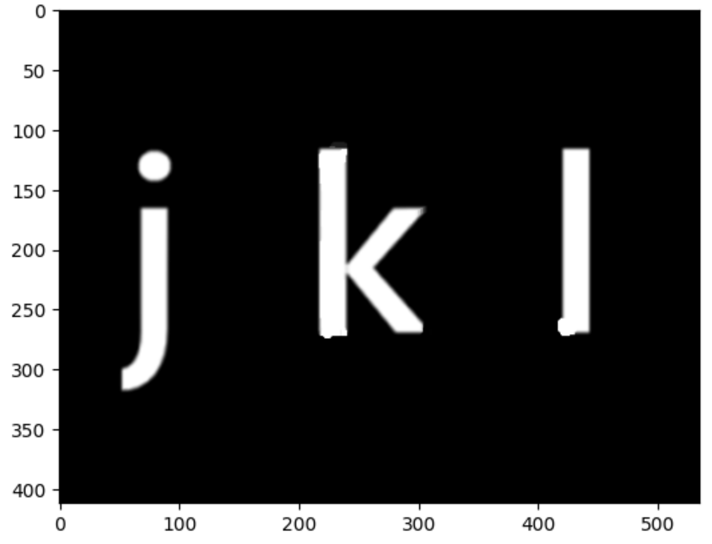
3. Opening

Opening is just another name of erosion followed by dilation. It is useful in removing noise, as we explained above. Here we use the function, cv.morphologyEx()

```
opening = cv.morphologyEx(img, cv.MORPH_OPEN, kernel)
plt.imshow(opening,cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d4a1f390>
```



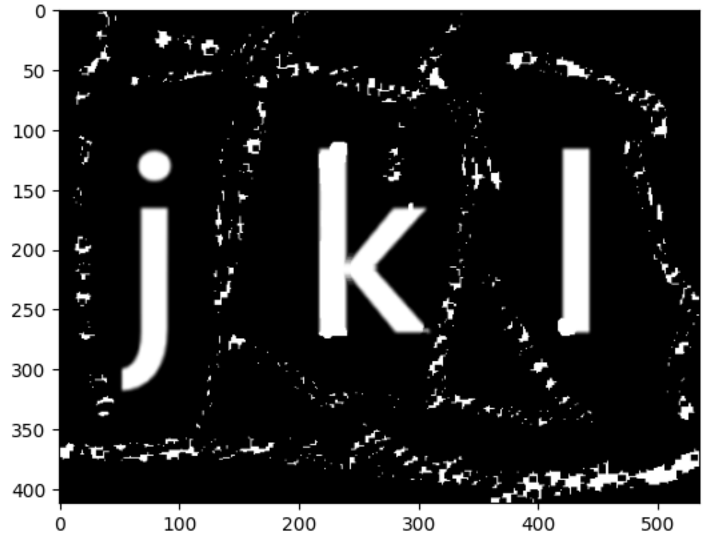
https://docs.opencv.org/4.x/d9/d61/tutorial_py_morphological_ops.html

4. Closing

Closing is reverse of Opening, Dilation followed by Erosion. It is useful in closing small holes inside the foreground objects, or small black points on the object. closing = cv.morphologyEx(img, cv.MORPH_CLOSE, kernel)

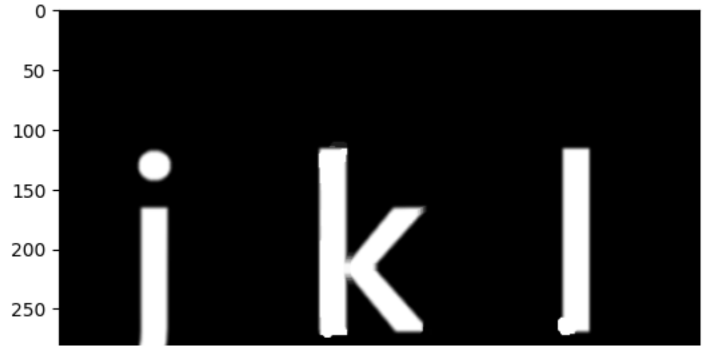
```
closing = cv.morphologyEx(img, cv.MORPH_CLOSE, kernel)
plt.imshow(closing,cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d460ed10>
```




```
closing = cv.morphologyEx(opening, cv.MORPH_CLOSE, kernel)
plt.imshow(closing,cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d4670990>
```



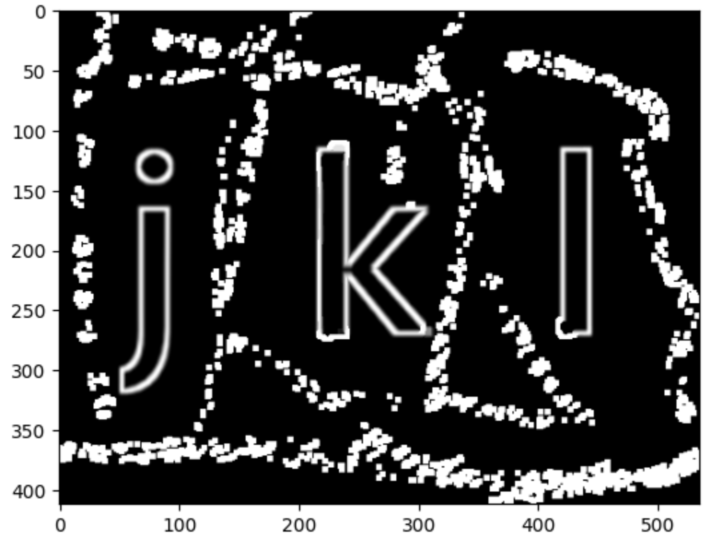
5. Morphological Gradient

It is the difference between dilation and erosion of an image.

The result will look like the outline of the object. gradient = cv.morphologyEx(img, cv.MORPH_GRADIENT, kernel)

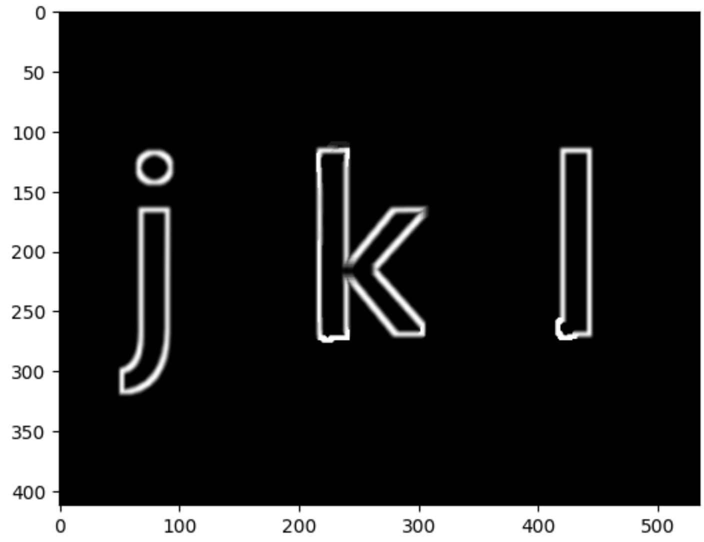
```
gradient = cv.morphologyEx(img, cv.MORPH_GRADIENT, kernel)
plt.imshow(gradient,cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d4b7b890>
```



```
gradient = cv.morphologyEx(closing, cv.MORPH_GRADIENT, kernel)
plt.imshow(gradient,cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d4bfded0>
```

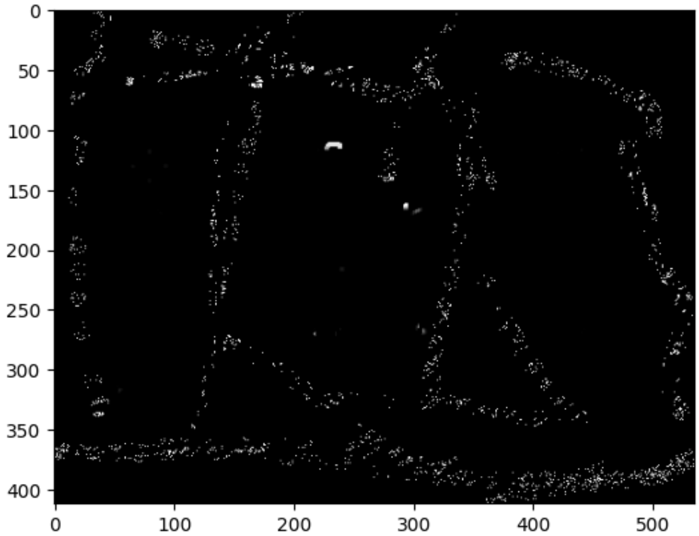


6. Top Hat

It is the difference between input image and Opening of the image. Below example is done for a 9x9 kernel. tophat = cv.morphologyEx(img, cv.MORPH_TOPHAT, kernel)

```
tophat = cv.morphologyEx(img, cv.MORPH_TOPHAT, kernel)
plt.imshow(tophat,cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d4a1ed10>
```

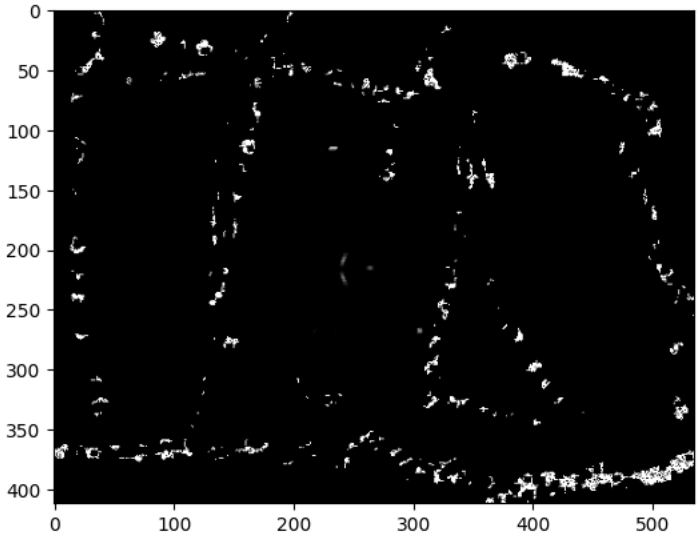


7. Black Hat

It is the difference between the closing of the input image and input image. blackhat = cv.morphologyEx(img, cv.MORPH_BLACKHAT, kernel)

```
blackhat = cv.morphologyEx(img, cv.MORPH_BLACKHAT, kernel)
plt.imshow(blackhat,cmap="gray")
```

```
<matplotlib.image.AxesImage at 0x296d4a5ed10>
```



Structuring Element

We manually created a structuring elements in the previous examples with help of Numpy. It is rectangular shape. But in some cases, you may need elliptical/circular shaped kernels. So for this purpose, OpenCV has a function, cv.getStructuringElement(). You just pass the shape and size of the kernel, you get the desired kernel.

```
cv.getStructuringElement(cv.MORPH_RECT,(5,5))
```

```
array([[1, 1, 1, 1, 1],
       [1, 1, 1, 1, 1],
       [1, 1, 1, 1, 1],
       [1, 1, 1, 1, 1],
       [1, 1, 1, 1, 1]], dtype=uint8)
```

```
cv.getStructuringElement(cv.MORPH_ELLIPSE,(5,5))
```

```
array([[0, 0, 1, 0, 0],
       [1, 1, 1, 1, 1],
       [1, 1, 1, 1, 1],
       [1, 1, 1, 1, 1],
       [0, 0, 1, 0, 0]], dtype=uint8)
```

```
cv.getStructuringElement(cv.MORPH_CROSS,(5,5))
```

```
array([[0, 0, 1, 0, 0],
       [0, 0, 1, 0, 0],
       [1, 1, 1, 1, 1],
       [0, 0, 1, 0, 0],
       [0, 0, 1, 0, 0]], dtype=uint8)
```

https://homepages.inf.ed.ac.uk/rbf/HIPR2/hitmiss.htm

https://homepages.inf.ed.ac.uk/rbf/HIPR2/skeleton.htm

https://homepages.inf.ed.ac.uk/rbf/HIPR2/thin.htm

https://homepages.inf.ed.ac.uk/rbf/HIPR2/thin.htm

https://towardsdatascience.com/understanding-morphological-image-processing-and-its-operations-7bcf1ed11756